SUBSTITUTE SECTION (MARKED-UP VERSION)

| Element Description | Element Number |
|---|---|
| Ramped Shoulder | 1 |
| Rotor Inner Peripheral Surface | 2 |
| Stator Interior End Face | 3 |
| Stator Exterior End Face | 4 |
| Stator Outer Peripheral Surface | 5 |
| Stator Interior Peripheral surface | 6 |
| Stator Unitizing Ring Groove | 7 |
| Rotor Unitizing Ring Groove | 8 |
| First Rotor/Stator Interface | 9 |
| Second Stator Annular Groove | 10 |
| Seal | 11 |
| Rotor | 12 |
| Stator | 13 |
| Housing | 14 |
| Shaft | 15 |
| Bearing | 16 |
| Rotor Annular Flange | 17 |
| Stator O-ring | 18 |
| Stator Annular (Deep) Groove | 19 |
| Inside Groove Sidewall | 19a |
| Outside Groove Sidewall | 19b |
| First Stator/Shaft Clearance Face | 19c |
| Second Stator/Shaft Clearance Face | 19d |
| Peripheral Groove Surface | 19e |
| Axial Slot | 20 |
| Trough | 20a |
| Unitizing Ring | 21 |
| Rotor Exterior End Face | 22 |
| Rotor O-ring | 23 |
| External Drain | 24 |
| Annular Stator Flange | 25 |
| First Annular Rotor Groove | 26 |
| Stator O-ring Groove | 27 |
| Rotor O-ring Groove | 28 |
| Second Annular Rotor Groove | 29 |
| Lubricant Sump | 30 |
| Exterior Annular Channel | 31 |
| Circumferential Channel Surface | 32 |
| Stator Outer Peripheral Groove | 33 |

| | |
|---|---|
| Linear Radial Interface | 34 |
| Vertical Interface | 35 |
| Second Rotor/Stator Interface | 36 |

[Referring to FIG. 1 which shows the seal 11 including rotor 12 and stator 13 in housing 14. Shaft 15 has a bearing 16 mounted on shaft 15. Rotor 12 is rotated with shaft 15 by o-ring 17. Stator 13 is affixed to the housing 16 by seal 18. Stator 13 also has a groove 19 formed by sidewalls 19a and 19b. This groove 19 should be as deep and wide as possible depending upon the radial cross-section and the material characteristics of the stator 11.] Referring now to the drawings, wherein like reference numerals designate identical or corresponding parts throughout the several views, FIG. 1 shows a seal 11 mounted in a housing 14 having a bearing 16 with a rotatable shaft 15 there-through. In applications where there is no risk of external contaminants entering the seal 11, the stator 13 alone is sufficient for lubricant retention and no rotor 12 is required. In the embodiment shown in FIGS. 1, 3 and 4, the stator 13 has opposite end faces, an interior end face 3 and an exterior end face 4, a first stator/shaft clearance face 19c (forming a portion of the inner periphery of the stator 13), a second stator/shaft clearance face 19d (forming another portion of the inner periphery of the stator 13), an interior peripheral surface 6, and an outer peripheral surface 5 with a ramped shoulder 1.

There may be more than one stator annular groove 19 (also referred to as a "Deep Groove"), however all material limitations must be observed with a plurality of grooves i.e., the radial cross section and material characteristics must still be limiting factors as to the depth and width of the stator annular groove 19. The opening of the stator annular (deep) groove 19 must be positioned to face the shaft 15.

As is best seen in FIG. 3 (a view of the stator 13 with no rotor 12 present), the stator 13 has a stator O-ring groove 27 in which a stator O-ring 18 is mounted for a frictional, gasketed fit within housing 14. In this embodiment a ramped shoulder 1 in the stator 13 limits the inward axially movement of the stator 13 with respect to the housing 14. The stator 13 is formed with an annular groove (stator annular "deep" groove 19) that in both the axial and radial dimensions is as large as physically practicable and allowed by the dimension and application of the seal 11. Stator annular "deep" groove 19 is defined by the inside groove sidewall 19a, outside groove sidewall 19b and the peripheral groove surface 19e. The stator annular "deep" groove 19 is in communication with the shaft 15 via the first stator/shaft clearance face 19c and the second stator/shaft clearance face 19d. When the shaft 15 rotates, it imparts kinetic energy to any lubricant that is on the shaft 15. Consequently, the lubricant on shaft 15 is flung from the shaft 15 and collected in the stator annular "deep" groove 19. Axial slot 20 is in communication with the stator annular "deep" groove 19 as shown in FIG. 2. In one embodiment, the axial slot 20 is an elongated hole (as shown in FIG. 2) in the stator interior end face 3, with a trough 20a forming the bottom surface. The stator 13 is situated within the housing 14 so that the axial slot 20 is in the gravitationally lowest position so that lubricant collected in the stator annular "deep" groove 19 will flow by gravity through axial slot 20. Axial slot 20 drains to a lubricant sump 30 in the housing 14 so that lubricant collected in the stator annular "deep" groove 19 is retained within the housing 14. The design of the stator annular "deep" groove 19 in the stator 13 being in direct communication with the shaft 15, with no rotor between said stator annular "deep" groove 19 and said shaft 15, provides for excellent lubricant retention in situations where a typical rotor/stator type seal 11 would have a propensity to leak, such as: unusually high lubricant levels, high lubricant turbulence caused by a cylindrical roller, meshing gears or similar bearings in which lubricant has a tendency to impinge on the trough 20a or applications using plain or sleeve bearings

(especially when pressure lubricated) in which the lubricant has a tendency to travel parallel to the shaft 15 and cause an external leak. A stator 13 may be fashioned with a plurality of annular "deep" grooves 19 in the axial dimension if such a configuration would yield superior lubricant retention in the desired application for the seal 11.

[There is an axial slot 20 incorporated to the stator 13 at the outer radial limits of groove 19. This slot 20 or hole includes a sloping surface or trough 20a to carry lubricant to the sump 30. The slot may be circular or elongated around the periphery of the stator wall 19a. Slot 20 may be a plurality of circumferential slots as shown in FIG. 2. Slot 20 intersects and penetrates into groove 19 at an angle to the shaft 15 and intersects the diameter of groove 19 at the outer diameter, approximately one-half of the diameter of the hole or orifice.] In the embodiment shown in FIG. 5, the stator 13 is fashioned with a plurality of axial slots 20 that are circular in shape. In this embodiment, the stator 13 may be rotated within the housing 14 while continually having a gravitationally low axial slot 20 available, making this embodiment particularly useful in applications in which the housing 14 of a rotating machine must be rotated to the correct axial position of the shaft 15. The peripheral groove surface 19e intersects the axial slots 20 so as to bisect the axial slots 20. In this embodiment, the axial slots 20 are positioned so that a line from the center of one axial slot 20 to the center of one adjacent axial slot 20 will not intersect the first stator/shaft clearance face 19c. In this way, in any orientation of the stator 13 about the housing 14, one of the axial slots 20 will be the gravitationally lowest point, so as to facilitate gravity draining of lubricant collected in the stator annular "deep" groove 19. Typically, axial s[S]lot 20 is as far away from shaft 15 and the stator 13 interface as possible.

[The inner radial surfaces of stator groove walls 19a and 19b should be as close to shaft 15 as possible. The radial dimension between shaft 15 and the seal faces 19c

should be in the range of 0.005 inches per inch of shaft diameter. As shown in FIG. 2 the stator may be rotated while always providing a fixed downward position of at least one drain hole for the draining of the lubricants back to the sump 30.] In applications where there is a possibility for external contaminants to enter the seal 11, a rotor 12 (as shown in FIGS. 1 and 4) is often employed in the seal 11 assembly. The rotor 12 has a rotor inner peripheral surface 2 in which a rotor O-ring groove 28 is formed. A rotor O-ring 23 is mounted in the rotor O-ring groove 28 to frictionally and sealingly mount the rotor 12 on the shaft 15 so that the rotor 12 rotates with the shaft 15. In this embodiment, the stator 13 functions in the same manner and is mounted within the housing 14 in the same manner as in the previously described embodiment employing only a stator 13. That is to say, even when a rotor 12 is included in the seal 11, the stator annular "deep" groove 19 in the stator 13 is in direct communication with the shaft 15. However, in this embodiment, the stator also includes an annular stator flange 25 that corresponds to a first annular rotor groove 26, and a stator annular groove 10 that corresponds to a rotor annular flange 17, all of which cooperate to form a labyrinth seal within the stator 13 and the rotor 12 to help seal the bearing 16 from external contaminants.

The rotor 12 and the stator 13 are unitized by a unitizing ring 21. The unitizing ring 21 seats within the stator unitizing ring groove 7 when the shaft 15 is not rotating (depicted in the embodiment shown in FIG. 1) and thereby seals the second rotor/stator interface 36 and second stator/shaft clearance face 19d, and consequently the stator annular "deep" groove 19, first stator/shaft clearance face 19c, the lubricant sump 30 and bearing 16 from the exterior annular channel 31 (which channel is described in detail below), the first rotor/stator interface 9 and the external environment. This sealing function is especially useful when the shaft 15 has been rotating and the housing 14, bearing 16 and the seal 11 are at a higher than ambient temperature and subsequent cooling as a result of non-

rotation of the shaft 15 causes the housing 14, bearing 16 and the seal 11 to cool and create a vacuum effect with the external environment. If the unitizing ring did not achieve the sealing function described above, the resulting pressure gradient would induce external contaminants to pass into the first rotor/stator interface 9 and from there into the seal 11 and the bearing 16, which contributes to premature bearing 16 failure. When the shaft 15 rotates the unitizing ring 21 also rotates, causing the unitizing ring 21 to expand radially and seat in the rotor unitizing ring groove 8. In this state, the unitizing ring 21 runs with no clearance with either the stator unitizing ring groove 7 or the rotor unitizing ring groove 8.

[As shown if FIG. 3, the stator 13 can operate alone where no external contaminants are to be encountered. The seal consisting only of stator 13 can be simplified in this case as no interplay or labyrinth required between the rotor and stator parts. This can greatly reduce costs of oil retention, if retention is the only requirement.] The rotor 12 and/or the stator 13 may be fashioned with an exterior annular channel 31 for collecting external contaminants that have passed through the first rotor/stator interface 9. FIG. 1 shows only the rotor 12 fashioned with an exterior annular channel 31, although a corresponding exterior annular channel 31 could be fashioned in the stator 13 in the presence or absence of the exterior annular channel 31 fashioned in the rotor 12. The exterior annular channel 31 communicates with the first rotor/stator interface 9 and the interface between the rotor annular flange 17 and the second stator annular groove 10. External contaminants from both the first rotor/stator interface 9 and the interface between the rotor annular flange 17 and the stator annular groove 10 are collected in the exterior annular channel 31. Centrifugal force imparted to external contaminants from the rotation of the rotor 12 causes the external contaminants to migrate onto the circumferential channel surface 32. An external drain 24 is positioned at the gravitationally lowest point of the stator 13 and communicates with the exterior annular channel 31 so that external contaminants

in the exterior annular channel 31 drain by gravity through the external drain and out of the seal 11. The contaminant expulsion is not assured when rotation of this seal 11 occurs. However[,] this invention provides that in one configuration [, the rotor 12, that] the diameter at [interference] interface of rotor 12 with stator 13 is greater than the diameter of stator 13. This differential creates a pumping action of contaminants outwardly at the rotor/stator interface because of ever increasing diameter in the direction of the intended path of contaminants expulsion and exclusion.

FIG. 4 provides another embodiment of the present invention. In the embodiment shown in FIG. 4, there is no external drain 24 fashioned in the stator 13. In this embodiment, the stator 13 includes a stator outer peripheral groove 33, the exterior wall of which is formed by a linear radial interface 34 between the stator 13 and the rotor 12, which is accomplished by extension in the radial direction of the annular stator flange 25, and consequently a similar extension of the first annular rotor groove 26. The lubricant retention function of this embodiment is substantially the same as that in the previous embodiments. However, in the embodiment shown in FIG. 4, the linear radial interface 34 between the stator 13 and the rotor 12 provides for a superior ability of the seal 11 to prevent entry of external contaminants into the first rotor/stator interface 9. In this embodiment, external contaminants entering the stator outer peripheral groove 33 are not prone to enter the first rotor/stator interface 9 due to the vertical interface 35 between the rotor 12 and the stator 13 and the centrifugal pumping action associated with the vertical interface 35 when the rotor 12 is rotating.

Bearing Isolator
David C. Orlowski
Application No.: 09/428,982
Attorney Docket No.: P3091

# CLEAN SET

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# MARKED UP SET

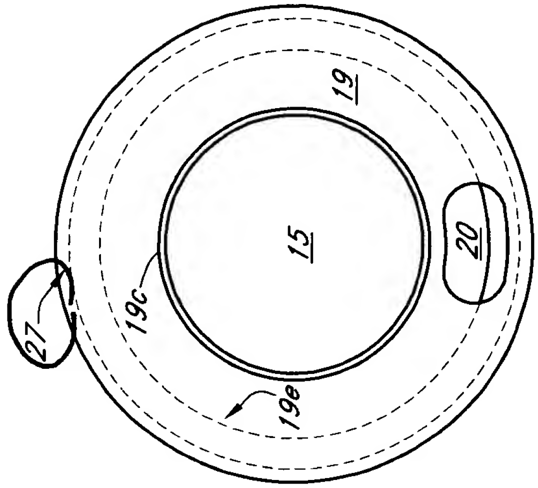


FIG. 2

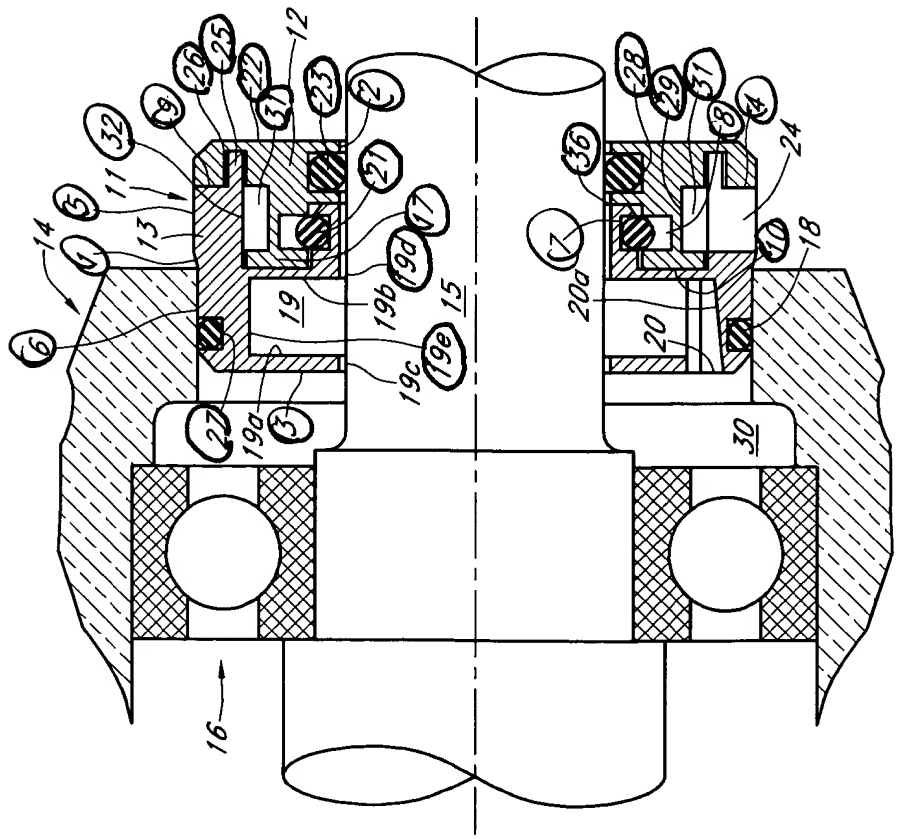


FIG. 1

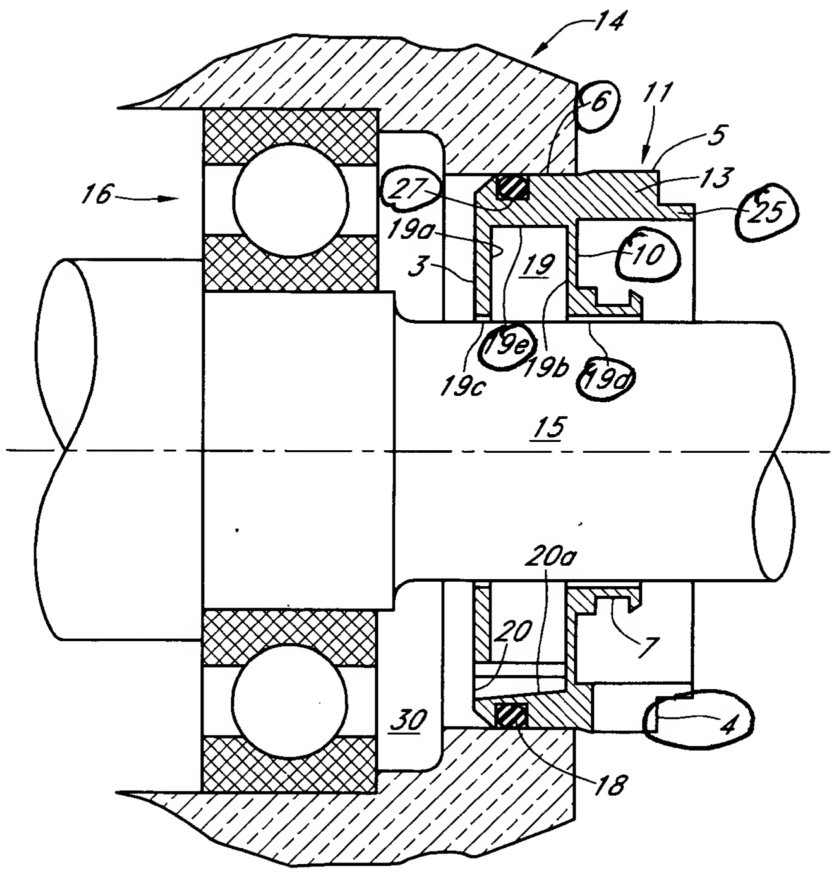
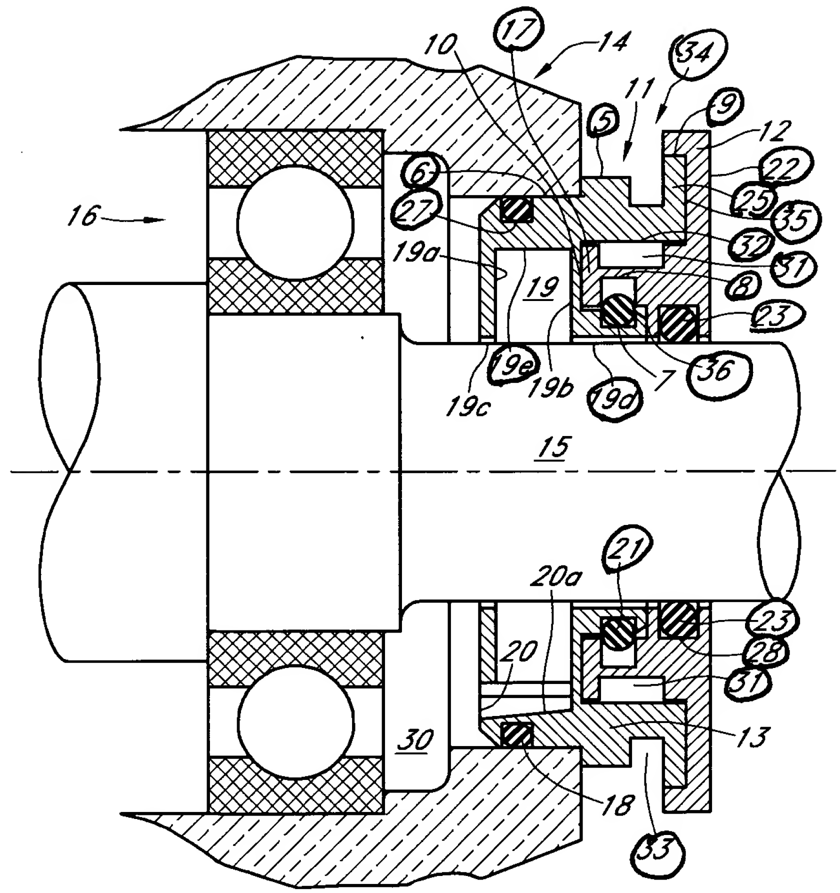



FIG. 3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19e
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FIG. 4

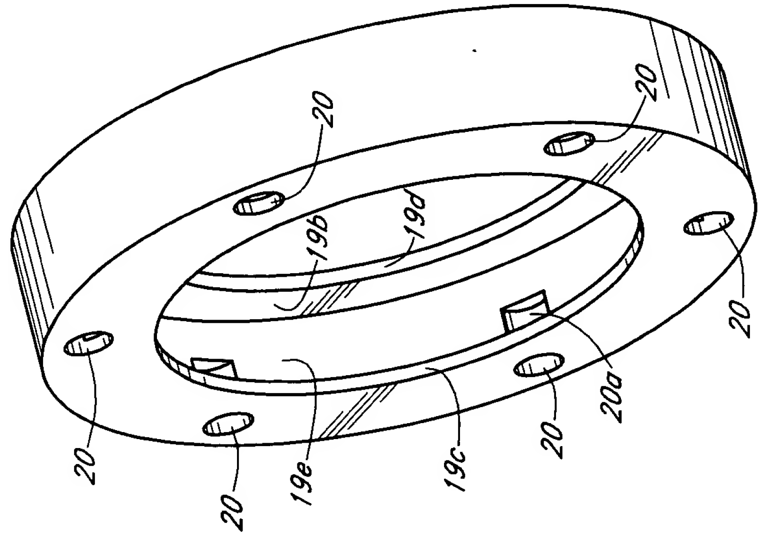
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FIG. 6

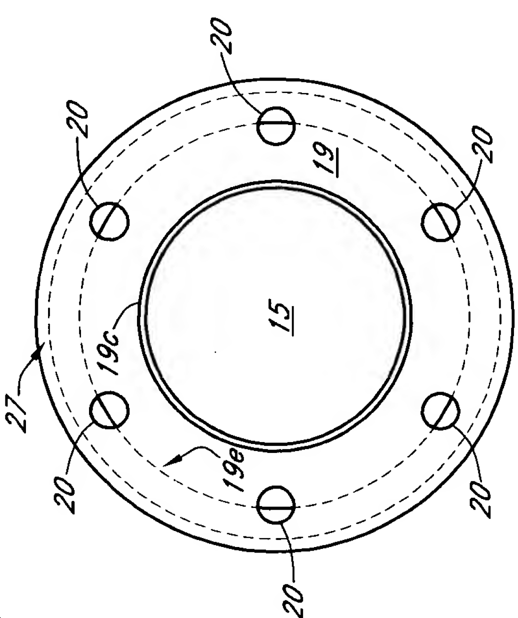
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FIG. 5